WE CLAIM:

1. A method for obtaining a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor exposed to incident light from the scene for capturing an image thereof, the image sensor having a multiplicity of light-sensing elements in an array, each light-sensing element having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and having a response function, each light-sensing element being responsive to incident light from the scene for producing a captured image brightness value at a corresponding one of a multiplicity of pixel positions of a pixel position array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels of the light-sensing elements, the method comprising the steps of:

(a) estimating respective off-grid brightness values at a multiplicity of off-grid positions from respective captured image brightness values at pixel positions of the pixel position array, the off-grid positions being located at respective interstices of the pixel position array and forming a regular off-grid position array; and

(b) deriving pixel brightness values of an output image from the estimated off-grid brightness values.

2. The method of claim 1, wherein the array of light-sensing elements of the image sensor is a linear array for capturing a line image, and the pixel position array is a linear array having

the multiplicity of pixel positions at respective regularly spaced pixel positions in a pixel row so as to define a linear captured image brightness value array.

3. The method of claim 1, wherein the array of light-sensing elements of the image sensor is a linear array and the pixel position array is a two-dimensional array haivng pixel positions at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns , the pixel rows being orthogonal to the pixel columns, and wherein the linear array of light-sensing elements of the image sensor is sequentially exposed to successive regularly spaced linear regions of the scene in multiple exposures, each one of the exposures producing a respective linear captured image brightness value array, the respective linear captured image brightness arrays produced by the multiple exposures being concatenated to form a two-dimensional captured image brightness value array having respective captured image brightness values at the pixel positions of the pixel position array.

4. The method of claim 1, wherein the image sensor has a two-dimensional array of light-sensing elements and the pixel position array is a two-dimensional array having the multiplicity of pixel positions at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns.

5. The method of claim 4, wherein the off-grid positions of the off-grid position array are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each one of the intermediate rows being parallel to the pixel rows and extending between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

6. The method of claim 4, wherein the off-grid positions of the off-grid position array are located at respective intersections of a plurality of regularly spaced intermediate rows and the pixel columns, and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows being parallel to the pixel rows and extending between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

7. The method of claim 3, wherein the off-grid positions of the off-grid position array are located at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

8. The method of claim 2, wherein the off-grid positions of the off-grid position array are located between respective adjacent pairs of pixel positions of the linear pixel position array.

9. The method of claim 1, wherein the step of deriving the output image from the estimated off-grid brightness values comprises using the estimated off-grid brightness values directly as the pixel brightness values of the output image.

10. The method of claim 1, wherein the step of deriving pixel brightness values of the output image from the estimated off-grid brightness values comprises resampling the estimated off-grid brightness values to derive respective resampled on-grid brightness values at the pixel positions of the pixel position array, the respective resampled on-grid brightness values at the pixel positions of the pixel position array being the pixel brightness values of the output image.

11. The method of claim 5, wherein the predetermined sensitivity pattern of the array of light-sensing elements has four different predetermined sensitivity levels and corresponds to a pixel position array having repetitive groups of four nearest neighbor pixel positions, each one of the four pixel positions in each group corresponding to a different one of the four predetermined sensitivity levels in a common predetermining positional order.

12. The method of claim 6, wherein the predetermined sensitivity pattern of the array of light-sensing elements has first and second predetermined sensitivity levels, and wherein adjacent pixel positions in each one of the pixel rows and adjacent pixel positions in each one of the pixel columns correspond to different ones of the first and second predetermined sensitivity levels.

13. The method of claim 7, wherein the predetermined sensitivity pattern of the array of light-sensing elements have first and second predetermined sensitivity levels, and adjacent pixel positions in each one of the pixel rows correspond to different ones of the predetermined first and second sensitivity levels, and adjacent pixel positions in each one of the pixel columns correspond to the same one of the predetermined first and second sensitivity levels.

14. The method of claim 1, wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises the steps of: (1) estimating a sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions using only captured image brightness values at pixel positions corresponding to the different one of the sensitivity levels; and (2) combining the sensitivity level off-grid brightness value estimated for each different one of the sensitivity levels

at each one of the off-grid positions to derive a respective estimated off-grid brightness values at each one of the off-grid positions.

15. The method of claim 14, wherein the step of combining the sensitivity level of brightness value for each different one of the sensitivity levels at each one of the off-grid positions comprises adding the sensitivity level off-grid brightness values estimated for each different one of the sensitivity levels at each one of the off-grid positions to derive the respective estimated off-grid brightness value at each one of the off-grid positions.

16. The method of claim 15, wherein the step of deriving pixel brightness values of the output image from the estimated off-grid brightness values comprises interpolating the estimated off-grid brightness values to derive respective interpolated on-grid brightness values at the pixel positions of the pixel position array, and compensating each one of the interpolated on-grid brightness values by the inverse of a combined response function of the light-sensing elements to obtain the pixel brightness values of the output image, the combined response function being the sum of weighted response functions of light-sensing elements having different ones of the sensitivity levels, each one of the weighted response functions being a response function of a light-sensing element having a respective one of the sensitivity levels multiplied by a predetermined weighting factor for the respective one of the sensitivity levels.

17. The method of claim 16, wherein the step of compensating each one of the interpolated on-grid brightness values by the inverse of the combined response function of the light-sensing elements comprises deriving from each one of the interpolated on-grid brightness values a respective index for a lookup table memory storing lookup table data representing the inverse of the combined response function of the light-sensing elements, retrieving from the lookup table memory a compensated interpolated on-grid brightness value corresponding to each index, and providing the compensated interpolated on-grid brightness values as the pixel brightness values of the output image.

18. The method of claim 14, wherein the step of combining the sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions comprises the steps of: (1) multiplying the sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions with a respective predetermined weighting factor corresponding to the different one of the sensitivity levels to derive a weighted sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions; and (2) adding the weighted sensitivity off-grid level brightness value for each different one of the sensitivity levels at each one of the off-grid positions to derive the respective estimated off-grid brightness value at each one of the off-grid positions.

19. The method of claim 18, wherein the step of deriving the pixel brightness values of the output image from the estimated off-grid brightness values comprises interpolating the estimated off-grid brightness values to derive respective interpolated on-grid brightness values at the pixel positions of the pixel position array, and compensating each one of the interpolated on-grid brightness values by the inverse of a combined response function of the light-sensing elements to derive the pixel brightness values of the output image, the combined response function being the sum of weighted response functions of the light-sensing elements having different ones of the sensitivity levels, each one of the weighted response functions being a response function of a light-sensing element having a respective one of the sensitivity levels multiplied by a predetermined weighting factor for the respective one of the sensitivity levels.

20. The method of claim 19 wherein the step of compensating each one of the interpolated brightness values by the inverse of a combined response function of the light-sensing elements comprises using each one of the interpolated on-grid brightness values to derive a respective index for a lookup table memory storing data representing the inverse of the combined response function of the light-sensing elements, retrieving from the lookup table memory a respective compensated interpolated on-grid brightness value corresponding to each index, and providing the compensated interpolated on-grid brightness values as the pixel brightness values of the output image.

21. The method of claim 1, wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises the steps of: (1) estimating a sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions using only the captured image brightness values at pixel positions corresponding to the different one of the sensitivity levels; (2) combining the sensitivity level off-grid brightness value estimated for each different one of the sensitivity levels at each one of the off-grid positions to derive a combined sensitivity level off-grid brightness value at each one of the off-grid positions; and (3) compensating the combined sensitivity level off-grid brightness value at each one of the off-grid positions by the inverse of a combined response function of the light-sensing elements to derive a respective estimated off-grid brightness value at each one of the off-grid positions, the combined response function being the sum of weighted response functions of light-sensing elements having different ones of the sensitivity levels, each one of the weighted response functions being a response function of a light-sensing element having a respective one of the sensitivity levels multiplied by a predetermined weighting factor for the respective one of the sensitivity levels.

22. The method of claim 21, wherein the step of compensating the combined sensitivity level off-grid brightness value at each one of the off-grid positions by the inverse of the combined response function of the light-sensing elements comprises using the combined

sensitivity level off-grid brightness value at each one of the off-grid positions to derive a respective index for a lookup table memory storing data representing the inverse of the combined response function of the light-sensing elements, retrieving from the lookup table a compensated combined sensitivity level off-grid brightness value corresponding to each index, and providing the compensated combined sensitivity level off-grid brightness values retrieved from the lookup table as the respective estimated off-grid brightness values at the off-grid positions.

23. The method of claim 21, wherein the step of combining the sensitivity level off-grid brightness value estimated for each different one of the sensitivity levels at each one of the off-grid positions comprises adding the sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions to derive the respective combined sensitivity level off-grid brightness values at the off-grid positions.

24. The method of claim 21, wherein the step of combining the sensitivity level off-grid brightness value estimated for each different one of the sensitivity levels at each one of the off-grid positions comprises the steps of: (1) multiplying the sensitivity level off-grid brightness value estimated for each different one of the sensitivity levels at each one of the off-grid positions by a respective predetermined weighting factor corresponding to the different one of the sensitivity levels to derive a weighted sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions; and (2) summing the

weighted sensitivity off-grid level brightness value for each different one of the sensitivity levels at each one of the off-grid positions to derive the combined sensitivity level off-grid brightness value at each one of the off-grid positions.

25. The method of claim 14 or 21, wherein the step of estimating the sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions comprises the steps of: (1) masking the pixel positions but leaving unmasked pixel positions corresponding to the different one of the sensitivity levels; and (2) estimating the sensitivity level off-grid brightness value for the different one of the sensitivity levels at the one of the off-grid positions to be equal to the captured image brightness value at the one of the unmasked pixel positions nearest the one of the off-grid positions.

26. The method of claim 24, wherein the array of light-sensing elements of the image sensor is a linear array and the pixel position array is a linear array having pixel positions at respective regularly spaced pixel positions in a pixel row and the off-grid positions of the off-grid position array are each located between respective pairs of adjacent pixel positions of the linear pixel position array, and wherein the step of estimating a sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions comprises providing as the sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions the captured image brightness

values at pixel positions corresponding to the different one of the sensitivity levels that is the nearest neighbor to the one of the off-grid positions.

27. The method of claim 26, wherein the predetermined sensitivity pattern of the light-sensing elements has first and second predetermined sensitivity levels, and adjacent pixel positions of the liner pixel position array correspond to different ones of the first and second predetermined sensitivity levels, and wherein the step of multiplying the sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions by a respective predetermined weighting factor corresponding to the different one of the sensitivity levels to derive a weighted sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions, and the step of summing the weighted sensitivity level off-grid brightness value for each different one of the sensitivity levels at each one of the off-grid positions to derive the combined sensitivity level off-grid brightness value at each one of the off-grid positions is expressed as

$$B(x') = W_1 I_c(x' - 0.5) + W_2 I_c(x' + 0.5),$$

where $B(x')$ is the combined sensitivity level off-grid brightness value at off-grid position x', W_1 is the predetermined weighting factor for the sensitivity level corresponding to pixel position $(x' - 0.5)$, W_2 is the weighting factor for the sensitivity level corresponding to pixel position $(x' + 0.5)$, $I_c(x' - 0.5)$ is the captured image brightness value at pixel position $(x' - 0.5)$ and

$I_c(x' + 0.5)$ is the captured image brightness value at pixel position $(x' + 0.5)$, and wherein the combined response function of the light-sensing elements is expressed as

$$S(E) = W_1 P_1(E) + W_2 P_2(E),$$

where $P_1(E)$ is the radiometric response function of a light-sensing element having the sensitivity level corresponding to pixel position $(x' - 0.5)$ and $P_2(E)$ is the radiometric response function of a light-sensing element having the sensitivity level corresponding to pixel position $(x' + 0.5)$.

28. The method of claim 1, wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises bi-linear sampling with interpolation of the captured image brightness values at the pixel positions.

29. The method of claim 1, wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises bi-cubic sampling with interpolation of the captured image brightness values at the pixel positions.

30. The method of claim 1, wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises estimating a a

respective off-grid brightness value at each individual one of the off-grid positions by comparing a respective captured image brightness value at each one of a predetermined number of pixel positions that are nearest neighbors to the individual one of the off-grid positions with a predetermined low threshold value and a predetermined high threshold value, computing the sum of the nearest neighbor pixel position captured image brightness values that are greater than the predetermined low threshold value and less than the predetermined high threshold value, and dividing the sum by the number of nearest neighbor pixel position brightness values included in the sum.

31. The method of claim 1, wherein the step of estimating off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises estimating a respective off-grid brightness value at each individual one of the off-grid positions by comparing a respective compensated captured image brightness value at each one of a predetermined number of pixel positions that are nearest neighbors to the individual one of the off-grid positions with a predetermined low threshold value a predetermined high threshold value, computing the sum of the compensated captured image brightness values at the nearest neighbor pixel positions that are greater than the predetermined low threshold value and less than the predetermined high threshold value, and deriving a respective estimated off-grid brightness value at the individual one of the off-grid positions by dividing the sum by the number of compensated captured image

brightness values at nearest neighbor pixel positions, the respective compensated captured image brightness value at each one of the nearest neighbor pixel positions being the captured image brightness value at the one of the nearest neighbor pixel positions compensated by the inverse of the response function of a light-sensing element having a sensitivity level corresponding to the one of the nearest neighbor pixel positions.

32. The method of claim 31, wherein the respective compensated captured image brightness value at each one of the nearest neighbor pixel positions is derived by using the captured image brightness value at the one of the nearest neighbor pixel positions to derive an index for a lookup table memory storing data representing the inverse response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and retrieving from the lookup table memory a compensated captured image brightness value corresponding to the index from lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level of the one of the nearest neighbor pixel positions.

33. The method of claim 5, wherein each one of the intermediate rows extends medially between a respective adjacent pair of the pixel rows and each one of the intermediate columns extends medially between a respective adjacent pair of the pixel columns, and wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position

array comprises estimating the brightness value at each one of the off-grid positions (x′,y′), where x′ has values from 1 to xSize−1, y′ has values from 1 to ySize−1, and xSize and ySize are the dimensions of the captured image in the direction of the pixel rows and the pixel columns, respectively, the step of estimating respective off-grid brightness values at each one of the off-grid positions (x′,y′) comprising:

(i) comparing a respective brightness value I(u,v) at each one of sixteen pixel positions (u,v) that are nearest neighbors to the one of the off-grid positions (x′,y′) with a predetermined low threshold value and a predetermined high threshold value, where u has values from x′ − 5 to x′ + 0.5 and v has values from y′ − 0.5 to y′ + 0.5;

(ii) for each one of the brightness values I(u,v) at the sixteen nearest neighbor pixel positions (u,v) that is greater than the predetermined low threshold value and less than the predetermined high threshold value, computing indices i and j of a 4 × 4 cubic interpolation kernel ϕ using the relations i = x′−u−1.5 and j = y′−v−1.5, and computing the quantities

$$\phi_{ij}^2 \frac{\phi_{ji} \, I(u,v)}{\sum_{ab} \phi_{ab}^2}$$

and ϕ_{ij}^2, where ϕ_{mn} is the value of the 4 × 4 cubic interpolation kernel ϕ at indices m and n;

(iii) adding the quantities

$$\phi_{ij}^2 \frac{\phi_{ji} \, I(u,v)}{\sum_{ab} \phi_{ab}^2}$$

computed in step (ii) to derive a first sum s;

(iv) adding the quantities ϕ_{ij}^2 computed in step (ii) to derive a second sum w; and

(v) computing the estimated brightness value at the one of the off-grid positions (x′,y′) by dividing the first sum s by the second sum w.

34. The method of claim 33, wherein the brightness value I(u,v) at nearest neighbor pixel position (u,v) compared with the predetermined low threshold and the predetermined high threshold value in step (i) is the captured image brightness value at pixel position (u,v).

35. The method of claim 33, wherein the brightness value I(u,v) at nearest neighbor pixel position (u,v) compared with the predetermined low threshold value and the predetermined high threshold value in step (i) is the captured image brightness value at pixel position (u,v) compensated by the inverse of a response function of a light-sensing element having the sensitivity level corresponding to pixel position (u,v).

36. The method of claim 35, wherein the captured image brightness value at each one of the nearest neighbor pixel positions (u,v) is compensated by the inverse of the response function of a light-sensing element having the sensitivity level corresponding to one of the nearest neighbor pixel positions (u,v) by using the captured image brightness value to derive an index for a lookup table memory storing data representing the inverse of response functions of light-

sensing elements having different ones of the plurality of sensitivity levels, and retrieving from the lookup table memory a compensated captured image brightness value corresponding to the index using lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the one of the nearest neighbor pixel positions (u,v), the retrieved compensated brightness value being the brightness value I(u,v) at the one of the nearest neighbor pixel positions (u,v).

37. The method of claim 2, wherein the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from the respective captured image brightness values at the pixel positions of the pixel position array comprises estimating the brightness value at each one of the off-grid positions x', where x' has values from 2 to $xSize - 2$, xSize being the dimension of the captured line image, the step of estimating the off-grid brightness value at each one of the off-grid positions x' comprising:

(i) comparing a respective brightness value I(k) at each one of four pixel positions k that are nearest neighbors to the one of the off-grid positions x' with a predetermined low threshold value and a predetermined high threshold value, where k has values from $x'-1.5$ to $x'+1.5$;

(ii) for each one of the brightness values I(k) at the four nearest neighbor pixel positions k that is greater than the predetermined low threshold value and less than the

predetermined high threshold value computing the quantity I(k) G(k−x′), where G(k−x′) is the value of a 4 × 1 Gaussian interpolation kernel G at position (k−x′);

(iii) adding the quantities I(k) G(k−x′) computed in step (ii) to derive a first sum p;

(iv) adding the quantities G(k−x′) used in the computations of step (ii) to derive a second sum q; and

(v) computing the estimated brightness value at the one of the off-grid position x′ by dividing the first sum p by the second sum q.

38. The method of claim 37, wherein the respective brightness value I(k) at nearest neighbor pixel position k compared with the predetermined low threshold value and the predetermined high threshold value in step (i) is the captured image brightness value at nearest neighbor pixel position k.

39. The method of claim 37, wherein the brightness value I(k) at nearest neighbor pixel position k compared with the predetermined low threshold value and the predetermined high threshold value in step (i) is the captured image brightness value at nearest neighbor pixel position k compensated by the inverse of a light-sensing element having the sensitivity level corresponding to pixel position k.

40. The method of claim 39, wherein the captured image brightness value at each one of the nearest neighbor pixel positions k is compensated by the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the one of the nearest neighbor pixel positions k by using the captured image brightness value at the one of the nearest neighbor pixel positions k to an index for a lookup table memory storing data representing the inverse of response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and retrieving from the lookup table memory a compensated captured image brightness value corresponding to the index using lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the one of the nearest neighbor pixel positions k, the retrieved compensated captured image brightness value being the brightness value I(k) at the one of the nearest neighbor pixel position k.

41. The method of claim 37, wherein the 4 × 1 Gaussian kernel G has the form:

1.0	7.7	7.7	1.0

.

42. The method of claim 10, wherein the step of resampling the estimated off-grid brightness values to derive respective resampled on-grid brightness values at the pixel positions

of the pixel position array comprises deriving the resampled brightness value at each individual one of the pixel positions by computing the product of respective off-grid brightness values at a predetermined number of off-grid positions that are nearest neighbors to the individual one of the pixel positions and cubic interpolation kernel having the same dimensions as the predetermined number of off-grid positions.

43. The method of claim 5, wherein the step of deriving pixel brightness values of an output image from the estimated off-grid brightness values comprises resampling the estimated off-grid brightness values to derive resampled on-grid brightness values at the pixel positions of the pixel position array, and wherein each one of the intermediate rows extends medially between a respective adjacent pair of pixel rows and each one of the intermediate columns extends medially between a respective adjacent pair of pixel columns, and wherein the resampled brightness value at each one of the multiplicity of pixel positions is computed by the relation:

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x-1.5 + i,\ y-1.5 + j)\phi_{ij},$$

where x has values from 2.5 to xSize−2.5, y has values from 2.5 to ySize −2.5, I(x−2, y−2) is the resampled on-grid brightness value at pixel position (x−2, y−2), B(x−1.5+i, y−1.5+j) is the estimated off-grid brightness value at off-grid position (x−1.5+i, y−1.5+j), i and j are indices of a 4 × 4 cubic interpolation kernel ϕ; the indices i and j each have values from 0 to 3, ϕ_{ij} is the

value of the interpolation kernel ϕ at indices i and j, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is the dimension of the captured image in the direction of the pixel columns.

44. The method of claim 33 or 43, wherein the 4×4 cubic interpolation kernel ϕ has the form:

0.043	-0.66	-0.661	0.043
-0.661	10.28	10.28	-0.661
-0.661	10.28	10.28	-0.661
0.043	-0.661	-0.661	0.043

j i .

45. The method of claim 2, wherein the step of deriving pixel brightness values of an output image from the estimated off-grid brightness values comprises resampling the estimated off-grid brightness values to derive resampled on-grid brightness values at pixel positions of the pixel position array, and wherein each off-grid position is located midway between a respective adjacent pair of pixel positions, and the resampled on-grid brightness values I_o at each one of the pixel positions x is computed by the relation:

$$I_o(x-3) = \sum_{k=-1.5}^{k=1.5} B(x+k)\psi(k),$$

where x is the coordinate of the pixel position having values from 3.5 to xSize−3.5, $I_o(x-3)$ is the resampled on-grid brightness value at pixel position (x−3), B(x+k) is the estimated off-grid

brightness value at off-grid position (x+k), k is a position of a 4 × 1 cubic interpolation kernel ψ, ψ(k) is the value of the cubic interpolation kernel ψ at position k, the position k has values from −1.5 to 1.5, and xSize is the dimension of the captured line image.

46. The method of claim 45 , wherein the 4 × 1 cubic interpolation kernel ψ has the form:

−0.96	13.44	13.44	−0.96

$\vec{k}$

47. The method of claim 6, wherein each one of the intermediate rows extends medially between a respective adjacent pair of the pixel rows and each one of the intermediate columns extends medially between a respective adjacent pair of the pixel columns, and the step of estimating respective off-grid brightness values at the off-grid positions of the off-grid position array from respective captured image brightness values at the pixel positions of the pixel position array comprises estimating the off-grid brightness value at each one of the off-grid positions (x′,y′), where x′ has values from 0.5 to xSize−0.5 and y′ has values from 1 to ySize−1 for off-grid positions located at respective intersections of the intermediate rows and the pixel columns, x′ has values from 1 to xSize−1 and y′ has values from 0.5 to ySize−0.5 for off-grid positions located at respective intersections of the pixel rows and the intermediate columns, and xSize and ySize are the dimensions of the captured image in the directions of the pixel rows and the pixel

columns, respectively, the step of estimating the brightness values at each one of the off-grid positions (x',y')comprising:

(i) for each one of the off-grid positions (x', y') computing coordinates (u, v) using the relations $u = x' + 0.5i - 0.5j$ and $v = y' - 1.5 + 0.5i + 0.5j$, where i and j are indices of a 4×4 cubic interpolation kernel ϕ, and each one of the indices i and j has values from 0 to 3;

(ii) for each pair of coordinates (u, v) computed in step (i) using indices i and j, determining whether the coordinates (u,v) are those of a pixel position;

(iii) if the coordinates (u, v) computed in step (i) are the coordinates of a pixel position, comparing a brightness value $I(u,v)$ at the pixel position (u,v) with a predetermined low-threshold value and a predetermined high threshold value;

(iv) if the coordinates (u, v) computed in step (i) using indices i and j are those of a pixel position and the brightness value $I(u,v)$ is greater than the predetermined low threshold value and less than the predetermined high threshold value, then compute the quantities:

$$\phi_{ij}^2 \frac{\phi_{ji}\, I(u,v)}{\sum_{ab} \phi_{ab}^2}$$

and ϕ_{ij}^2, where $\phi_{m,n}$ is the value of a 4 x 4 cubic interpolation kernel ϕ at indices m and n;

(v) adding the quantities

$$\phi_{ij}^2 \frac{\phi_{ji}\, I(u,v)}{\sum_{ab} \phi_{ab}^2}$$

computed in step (iv) to derive a first sum s;

(vi) adding the quantities ϕ_{ij}^2 computed in step (iv) to derive a second sum w; and

(vii) computing the estimated brightness value at the one of the off-grid positions (x', y') by dividing the first sum s by the second sum w.

48. The method of claim 47, wherein the brightness value I(u,v) at each one of the pixel positions (u,v) compared with the predetermined low threshold value and the predetermined high threshold value in step (iii) is the captured image brightness value at the one of the pixel positions (u,v).

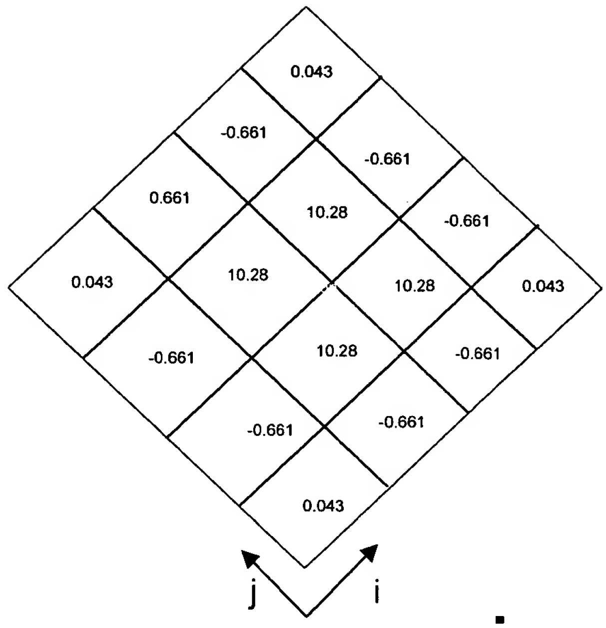
49. The method of claim 47, wherein the brightness value I(u,v) at each one of the pixel positions (u,v) compared with the predetermined low threshold value and the predetermined high threshold value in step (iii) is the captured image brightness value at the one of the pixel positions (u,v) compensated by the inverse of the response function of a light-sensing element having a sensitivity level corresponding to the one of the pixel positions (u,v).

50. The method of claim 49, wherein the captured image brightness value at each one of the pixel positions (u,v) is compensated by the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the one of the pixel positions (u,v) by using the captured image brightness value $I_c(u,v)$ at the one of the pixel positions (u,v) to derive an

index for a lookup table memory storing data representing the inverse of response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and retrieving from the lookup table a compensated captured image brightness value corresponding to the index using lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the one of the pixel positions (u,v), the retrieved compensated captured image brightness value being the brightness value I(u,v) at the one of the pixel positions (u,v).

51. The method of claim 47, wherein the step of estimating the off-grid brightness value at each one of the off-grid positions (x', y') is first carried out for off-grid positions located at respective intersections of intermediate rows and pixel columns, and then carried out for pixel positions located at respective intersections of pixel rows and intermediate columns.

52. The system of claim 47, wherein the 4 X 4 cubic interpolation kernel ϕ has the form:



53. The method of claim 6, wherein the step of deriving pixel brightness values of an output image from the estimated off-grid brightness values comprises resampling the estimated off-grid brightness values to derive respective resampled on-grid brightness values at pixel positions of the pixel position array, and each one of the intermediate rows extends medially between a respective adjacent pair of the pixel rows and each one of the intermediate columns extends medially between a respective adjacent pair of the pixel columns, and wherein the resampled on-grid brightness value at each one of the pixel positions (x,y) is computed by the relation:

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x+0.5i-0.5j,y-1.5+0.5i+0.5j)\phi_{ij},$$

where x has values from 2.5 to xSize -2.5, y has values from 2.5 to ySize -2.5, $I(x-2, y-2)$ is the resampled on-grid brightness value at pixel position $(x-2, y-2)$, $B(x+0.5i-0.5j,y-1.5+0.5i+0.5j)$ is the off-grid brightness value at off-grid position $(x+0.5i-j0.5j, y-1.5+0.5i+0.5j)$, i and j are indices of a 4×4 cubic interpolation kernel ϕ, indices i and j each have values from 0 to 3, ϕ_{ij} is the value of the interpolation kernel ϕ at indices i and j, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is the dimension of the captured image in the direction of the pixel columns.

54. The method of claim 5, wherein the step of deriving pixel brightness values of an output image from the estimated off-grid brightness values comprises using a Gaussian kernel for interpolating the estimated off-grid brightness values to derive respective interpolated brightness values at the pixel positions of the pixel position array.

55. The method of claim 54, wherein the Gaussian kernel has the form:

0.0037	0.0101	0.0166	0.0166	0.0101	0.0037
0.0101	0.0275	0.0452	0.0452	0.0275	0.0101
0.0166	0.0452	0.0743	0.0743	0.0452	0.0166
0.0166	0.0452	0.0743	0.0743	0.0452	0.0166
0.0101	0.0275	0.0452	0.0452	0.0275	0.0101
0.0037	0.0101	0.0166	0.0166	0.0101	0.0037

j i .

56. The method of claim 5, wherein the step of deriving pixel brightness values of an output image from the estimated off-grid brightness values comprises using a bi-linear interpolation filter kernel for interpolation of the off-grid brightness values to derive respective interpolated on-grid brightness values at the pixel positions of the pixel position array.

57. The method of claim 56, wherein the bi-linear interpolation filter kernel has the form:

0.5	0.5
0.5	0.5

j i .

58. The method of claim 5 or 7, wherein the step of deriving pixel brightness value of an output image from the estimated off-grid brightness values comprises resampling the estimated off-grid brightness values to derive respective resampled on-grid brightness values at

the pixel positions of the pixel position array, and wherein the step of resampling the estimated off-grid brightness values comprises shifting the off-grid position array to coincide with the pixel position array, whereby the resampled on-grid brightness values at the pixel positions of the pixel position array are the respective estimated off-grid brightness values at the coincident off-grid positions of the shifted off-grid position array.

59. A method for obtaining a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor exposed to incident light from the scene for capturing an image thereof, the image sensor having a multiplicity of light-sensing elements in an array, each light-sensing element having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and having a respective response function, each light-sensing element being responsive to incident light from the scene for producing a captured image brightness value at a corresponding one of a multiplicity of pixel positions of a pixel position array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels of the light-sensing elements, the method comprising the steps of computing respective on-grid brightness values at pixel positions of the pixel position array from respective captured image brightness values at the pixel positions of the pixel position array, each one of the respective on-grid brightness values being computed from a corresponding plurality of the

captured image brightness values, and deriving pixel brightness values of an output image from the on-grid brightness values.

60. The method of claim 59, wherein the array of light-sensing elements of the image sensor is a linear array for capturing a line image, and the pixel position array is a linear array having the multiplicity of pixel positions at respective regularly spaced pixel positions in a pixel row so as to form a linear captured image brightness value array.

61. The method of claim 59, wherein the array of light-sensing elements of the image sensor is a linear array and the pixel position array is a two-dimensional array having pixel positions at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the linear array of light-sensing elements of the image sensor is sequentially exposed to successive regularly spaced linear regions of the scene in multiple exposures, each one of the exposures producing a respective linear captured image brightness value array, the respective linear captured image brightness value arrays produced by the multiple exposures being concatenated to form a two-dimensional captured image brightness value array having respective captured image brightness values at the pixel positions of the pixel position array.

62. The method of claim 59, wherein the image sensor has a two-dimensional array of light-sensing elements, and the pixel position array is a two-dimensional array having the multiplicity of pixel positions at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns.

63. The method of claim 59, wherein the step of deriving pixel brightness values of an output image from the on-grid brightness values comprises using the respective on-grid brightness values at the pixel positions of the pixel position array as the pixel brightness values of the output image.

64. The method of claim 59, wherein the step of deriving pixel brightness values of an output image from the on-grid brightness values comprises compensating the respective on-grid brightness value at each one of the pixel positions of the pixel position array by the inverse of a combined response function of the light-sensing elements to obtain respective pixel brightness values of the output image at the pixel positions of the pixel position array, the combined response function being the sum of weighted response functions of the light-sensing elements having different ones of the plurality of sensitivity levels, each one of the weighted response functions being the response function of a light-sensing element having a respective one of the

sensitivity levels multiplied by a predetermined weighting factor for the respective one of the sensitivity levels.

65. The method of claim 64, wherein the step of compensating the on-grid brightness value at each one of the pixel positions of the pixel position array comprises the steps of deriving from the on-grid brightness value at each one of the pixel positions a respective index for a lookup table memory storing data representing the inverse of the combined response function of the light-sensing elements, and retrieving from the lookup table memory a compensated on-grid brightness value corresponding to the respective index, the compensated on-grid brightness value being the pixel brightness value of the output image at the one of the pixel positions.

66. The method of claim 59, wherein the step of computing respective on-grid brightness values at pixel positions of the pixel position array comprises computing the respective on-grid brightness value at each one of the pixel positions by calculating the product of the captured image brightness values at a predetermined number of pixel positions that are nearest neighbors to the one of the pixel positions and an on-grid interpolation filter kernel having the same dimensions as the predetermined number of pixel positions.

67. The method of claim 66, wherein the image sensor has a two-dimensional array of light-sensing elements, and the pixel array is a two-dimensional array having the multiplicity of

pixel positions at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the on-grid brightness value at each one of the pixel positions (x,y) of the pixel position array is calculated by the relation

$$I(x-2, y-2) = \sum_{i=o}^{4} \sum_{j=0}^{4} I_c(x-2+i, y-2+j)\phi_{ij},$$

where x has values from 2.5 to xSize - 2.5, y has values from 2.5 to ySize - 2.5, I(x - 2, y - 2) is the interpolated brightness value at pixel position (x - 2, y - 2), I_c(x - 2 + i, y - 2 + j) is the captured image brightness value at pixel position (x - 2 + i, y - 2 + j), i and j are indices of a 5 x 5 on-grid interpolation filter kernel ϕ, the indices i and j each have values from 0 to 4, ϕ_{ij} is the value of the on-grid interpolation filter kernel ϕ at indices i and j, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is the dimension of the captured image in the direction of the pixel columns.

68. The method of claim 67, wherein the 5×5 on-grid interpolation filter kernel ϕ has the form:

0.043	-0.618	-1.322	0.618	0.043
-0.618	9.001	19.238	9.001	-0.618
-1.322	19.238	41.12	19.238	-1.322
-0.618	9.001	19.238	9.001	-0.618
0.043	-0.618	-1.322	-0.618	0.043

j

i

69. The method of claim 59, wherein the step of computing respective on-grid brightness values at pixel positions of the pixel position array comprises computing a respective on-grid brightness value at each individual one of the pixel positions of the pixel position array including the steps of :

(i) comparing a respective compensated captured image brightness value at each one of a predetermined number of pixel positions that are nearest neighbors to the individual one of the pixel positions with a predetermined low threshold value and a predetermined high threshold value;

(ii) for each one of the nearest neighbor pixel positions having a compensated captured image brightness value greater than the predetermined low threshold value and less than the predetermined high threshold value, computing the product of the compensated captured image

brightness value at the one of the nearest neighbor pixel positions and the value of an on-grid interpolation filter kernel corresponding to the one of the nearest neighbor pixel positions, the on-grid interpolation filter kernel having the same dimensions as the predetermined number of nearest neighbor pixel positions;

(iii) computing a first sum of all products computed in step (ii);

(iv) computing a second sum of all values of the on-grid interpolation filter kernel used to compute a product in step (ii); and

(v) computing the on-grid brightness value at the individual one of the pixel positions by dividing the first sum by the second sum, wherein the respective compensated captured image brightness value at each one of the nearest neighbor pixel positions is the respective captured image brightness value at the one of the nearest neighbor pixel positions compensated by the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the one of the nearest neighbor pixel positions.

70. The method of claim 69, further comprising the steps of using the captured image brightness value at each one of the pixel positions of the pixel position array to derive a respective index for a lookup table storing data representing the inverse of response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and retrieving from the lookup table a compensated captured image brightness value corresponding to the respective index from lookup table data representing the inverse of the response function of the

light-sensing element having the sensitivity level corresponding to the one of the pixel positions, the retrieved compensated captured image brightness value being the compensated captured image brightness value at the one of the pixel positions.

71. A method for obtaining a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor exposed to incident light from the scene for capturing an image thereof, the image sensor having a multiplicity of light-sensing elements in a linear array, each light-sensing element having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and having a respective response function, each light-sensing element being responsive to incident light from the scene for producing a captured image brightness value at a corresponding one of a multiplicity of pixel position at respective regularly spaced pixel positions of a linear pixel position array to form a linear captured image brightness value array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels, the method comprising the steps of:

(i) for each one of the pixel positions x of the pixel position array, where x has values from 2.5 to xSize−2.5 and xSize is the dimension of the captured image, comparing each one of brightness values I(k) at five pixel positions k that are nearest neighbors to pixel position x with a predetermined low threshold value and a predetermined high threshold value, where k has values from x−2 to x+2;

(ii) for each one of the brightness values I(k) at the five nearest neighbor pixel positions k that is greater than the predetermined low threshold value and less than the predetermined high threshold value, computing the quantity I(k)G(k−x), where G(k−x) is the value of a Gaussian interpolation kernel G at position (k−x);

(iii) adding the quantities I(k)G(k−x) computed in step (ii) to derive a first sum p;

(iv) adding the Gaussian interpolation kernel values G(k−x) for all values of k where I(k) is greater than the predetermined low threshold value and less than the predetermined high threshold value to derive a second sum q; and

(v) computing a pixel brightness value of an output image $I_o(x)$ at pixel position x by dividing the first sum p by the second sum q.

72. The method of claim 71, wherein the brightness value I(k) at pixel position k compared with the predetermined low threshold value and the predetermined high threshold value in step (i) is the captured image brightness value at pixel position k.

73. The method of claim 71, wherein the brightness value I(k) at pixel position k compared with the predetermined low threshold value and the predetermined high threshold value in step (i) is the captured image brightness value at pixel position k compensated by the inverse of response function of a light-sensing element having a sensitivity level corresponding to pixel position k.

74. The method of claim 73, wherein the captured image brightness value at pixel position k is compensated by the inverse of the response function of a light-sensing element having a sensitivity level corresponding to pixel position k by using the captured image brightness value at pixel position k to derive a respective index for a lookup table memory storing data representing the inverse of response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and retrieving from the lookup table memory a compensated captured image brightness value I(k) corresponding to the respective index using lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level corresponding to pixel position k.

75. The method of claim 72, wherein the 5×1 Gaussian kernel G has the form:

0.1	3.6	10.0	3.6	0.1

$\vec{k}$.

76. The method of claim 31, 35, 39, 49, 69 or 73, wherein the predetermined low threshold value is the noise level of a light-sensing element having the sensitivity level corresponding to the pixel position having the compensated brightness value being compared therewith compensated by the inverse of the response function of a light-sensing element having

the corresponding sensitivity level, and the predetermined high threshold value is the saturation or near saturation brightness value of a light-sensing element having the same sensitivity level.

77. A system for obtaining capturing a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor adapted to be exposed to incident light from the scene for capturing an image thereof comprising:

(a) an image sensor having a multiplicity of light-sensing elements in an array, each light-sensing element having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and a respective response function, each light-sensing element being responsive to incident light from the scene for producing a captured image brightness value at a corresponding one of a multiplicity of pixel positions of a pixel position array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels of the light-sensing elements;

(b) a captured image memory for storing the captured image brightness values produced by the light-sensing elements at corresponding ones of the multiplicity of pixel positions of the pixel position array;

(c) an off-grid estimator for deriving from the captured image brightness values in the captured image memory respective estimated off-grid brightness values at a multiplicity of off-

grid positions located at respective interstices of the pixel position array so as to form a regular off-grid position array; and

(d) an output image generator for deriving pixel brightness values of an output image from the estimated off-grid brightness values.

78. The system of claim 77, wherein the array of light-sensing elements of the image sensor is a linear array for capturing a line image and the pixel position array is a linear array having the multiplicity of pixel positions located at respective regularly spaced positions in a pixel row so as to form a linear captured image brightness value array, the captured image memory for storing the captured image brightness values produced by the light-sensing elements.

79. The system of claim 78, wherein the off-grid positions of the off-grid position array are located between respective adjacent pairs of pixel positions of the linear pixel position array.

80. The system of claim 79, wherein the predetermined sensitivity pattern has a predetermined first sensitivity level and a predetermined second sensitivity level, and adjacent pixel positions of the linear pixel position array correspond to different ones of the predetermined first sensitivity level and the predetermined second sensitivity level.

81. The system of claim 77, wherein the array of light-sensing elements of the image sensor is a linear array and the pixel position array is a two-dimensional array having pixel positions at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the linear array of light-sensing elements of the image sensor is adapted to be sequentially exposed to successive regularly spaced linear regions of the scene in multiple exposures, each one of the exposures producing a respective linear captured image brightness value array, the respective linear captured image brightness value arrays produced by the multiple exposures being concatenated to form a two-dimensional captured image brightness value array having respective captured image brightness values at the pixel positions of the pixel position array, the concatenated linear captured image brightness value arrays being stored in the captured image memory as respective captured image brightness values at the pixel positions of the two-dimensional pixel position array.

82. The system of claim 81, wherein the off-grid positions of the off-grid position array are located at respective intersections of a plurality of regularly spaced intermediate columns and pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

83. The system of claim 82, wherein the predetermined sensitivity pattern has a first predetermined sensitivity level and a second predetermined sensitivity level, and wherein adjacent pixel positions in each one of the pixel rows correspond to different ones of the first and second predetermined sensitivity levels, and adjacent pixel positions in each one of the pixel columns correspond to the same one of the first and second predetermined sensitivity levels.

84. The system of claim 77, wherein the image sensor has a two-dimensional array of light-sensing elements and the multiplicity of pixel positions are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, the captured image memory for storing the captured image brightness values produced by the light-sensing elements at corresponding ones of the multiplicity of pixel positions of the pixel position array.

85. The system of claim 84 wherein the off-grid positions of the off-grid position array are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each intermediate row being parallel to the pixel rows and extending between a respective adjacent pair of pixel rows and each intermediate column being parallel to the pixel columns and extending between a respective adjacent pair of pixel columns.

86. The system of claim 85, wherein the predetermined sensitivity pattern of the array of light-sensing elements has four different predetermined sensitivity levels and corresponds to a repetitive pattern of groups of four nearest neighbor pixel positions, each one of the four pixel positions in each group corresponding to a different one of the four predetermined sensitivity levels in a common predetermined positional order.

87. The system of claim 84, wherein the off-grid positions of the off-grid position array are located at respective intersections of a plurality of regularly spaced intermediate rows and the plurality of pixel columns, and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows being parallel to the pixel rows and extending between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of pixel columns.

88. The system of claim 87, wherein the predetermined sensitivity pattern of the array of light-sensing elements has first and second predetermined sensitivity levels, and wherein adjacent pixel positions in each one of the pixel rows and adjacent pixel positions in each one of the pixel columns correspond to different ones of the first and second predetermined sensitivity levels.

89. The system of claim 77, wherein the output image generator comprises an output image memory for storing the respective estimated off-grid brightness values derived by the off-grid estimator as the pixel brightness values of the output image.

90. The system of claim 77, wherein the output image generator comprises:

(a) an off-grid brightness value memory for storing the estimated off-grid brightness values derived by the off-grid estimator;

(b) an on-grid resampler for deriving from the estimated off-grid brightness values in the off-grid brightness value memory respective resampled on-grid brightness values at the pixel positions of the pixel position array; and

(c) an output image memory for storing the respective resampled on-grid brightness values derived by the on-grid resampler as the pixel brightness values of the output image.

91. The system of claim 77, wherein the off-grid estimator comprises:

(a) an off-grid position generator for providing the off-grid positions of the off-grid position array;

(b) a sensitivity pattern memory for storing data indicative of the sensitivity level corresponding to each one of the pixel positions of the pixel position array;

(c) a plurality of sensitivity level off-grid brightness value estimators each corresponding to a respective one of the plurality of sensitivity levels of the light-sensing elements, and

receiving off-grid positions from the off-grid position generator and sensitivity pattern data from the sensitivity pattern memory, each one of the sensitivity level off-grid brightness value estimators being responsive to an off-grid position received from the off-grid position generator and the sensitivity pattern data from the sensitivity pattern memory for deriving from the captured image brightness values in the captured image memory a respective sensitivity level off-grid brightness value for the corresponding sensitivity level at the received off-grid position; and

(d) an accumulator for combining the respective sensitivity level off-grid brightness values derived by the plurality of sensitivity level off-grid brightness value estimators for the corresponding sensitivity levels at each off-grid position received from the off-grid position generator to derive a respective estimated off-grid brightness value at each off-grid position received from the off-grid position generator.

92. The system of claim 90, wherein the on-grid resampler comprises:

(i) a pixel position generator for providing the pixel positions of the pixel position array;

(ii) an interpolator for receiving pixel positions provided by the pixel position generator and being responsive to a pixel position received from the pixel position generator for deriving from the estimated off-grid brightness values in the off-grid brightness value memory a respective interpolated on-grid brightness value at the received pixel position; and

(iii) a response function compensator for compensating the respective interpolated on-grid brightness value derived by the interpolator at each pixel position received from the pixel position generator by the inverse of a combined response function of the light-sensing elements to derive a respective resampled on-grid brightness value at each pixel position received from the pixel position generator, the combined response function of the light-sensing elements being the sum of weighted response functions of light-sensing elements having different ones of the sensitivity levels, each one of the weighted response functions being a response function of a light-sensing element having a respective one of the sensitivity levels multiplied by a predetermined weighting factor for the respective one of the sensitivity levels.

93. The system of claim 92, wherein the response function compensator comprises a lookup table memory storing data representing the inverse of the combined response function of the light-sensing elements and a mapper for deriving from the respective interpolated on-grid brightness value derived by the interpolator at a received pixel position a respective index for the lookup table memory and providing a data value in the lookup table memory corresponding to the respective index to the output image memory, the data value being the pixel brightness value of the output image at the received pixel position.

94. The system of claim 91, wherein the accumulator comprises an adder for adding the sensitivity level off-grid brightness values derived by the plurality of sensitivity level off-grid

brightness value estimator for corresponding sensitivity levels at each received off-grid position to derive the respective estimated off-grid brightness value at each off-grid positions received from the off-grid position generator.

95. The system of claim 91, wherein the accumulator comprises a weighting factor memory for storing a plurality of predetermined weighting factors each corresponding to a different one of the plurality of sensitivity levels of the light-sensing elements, a plurality of multipliers each for multiplying the sensitivity level off-grid brightness value corresponding to a respective one of the sensitivity levels at a received off-grid position by the weighting factor corresponding to the respective one of the sensitivity levels to provide a respective weighted sensitivity level off-grid brightness value for the corresponding sensitivity level at the received off-grid position, and an adder for summing the respective weighted sensitivity level off-grid brightness values provided by the plurality of multipliers to derive a respective estimated off-grid brightness value at the received off-grid position received from the off-grid position generator.

96. The system of claim 77, wherein the off-grid estimator comprises:

(a) an off-grid position generator for providing the off-grid positions of the off-grid position array;

(b) a sensitivity pattern memory for storing data indicative of the sensitivity level corresponding to each one of the pixel positions of the pixel position array;

(c) a plurality of sensitivity level off-grid brightness value estimators, each corresponding to a respective one of the sensitivity levels, for receiving off-grid positions from the off-grid position generator and sensitivity pattern data from the sensitivity pattern memory, each one of the plurality of sensitivity level off-grid brightness value estimators being responsive to an off-grid position received from the off-grid position generator and the sensitivity pattern data from the sensitivity pattern memory for deriving from the captured image brightness values in the captured image memory a respective sensitivity level off-grid brightness value for the corresponding sensitivity level at the received off-grid position;

(d) an accumulator for combining the respective sensitivity level off-grid brightness values derived by the plurality of sensitivity level off-grid brightness value estimator for the corresponding sensitivity levels at each off-grid position received from the off-grid position generator to derive a respective combined sensitivity level off-grid brightness value at each off-grid position received from the off-grid position generator; and

(e) a response function compensator for compensating the respective combined sensitivity level off-grid brightness value at each off-grid position received from the off-grid position generator by the inverse of a combined response function of the light-sensing elements to derive a respective estimated off-grid brightness value at each off-grid position received from the off-grid position generator, the combined response function being the sum of weighted response functions of light-sensing elements having different ones of the plurality of sensitivity levels, each one of the weighted response functions being a response function of a light-sensing element

having a respective one of the sensitivity levels multiplied by a predetermined weighting factor for the respective one of the sensitivity levels.

97. The system of claim 96, wherein the response function compensator comprises a lookup table memory storing lookup table data representing the inverse of the combined response function of the light-sensing elements, and a mapper for deriving from the respective combined sensitivity level off-grid brightness value at each off-grid position received from the off-grid position generator a respective index for the lookup table memory and providing a data value in the lookup table memory corresponding to the respective index as the respective estimated off-grid brightness value at the off-grid position received from the off-grid position generator.

98. The system of claim 96, wherein the output image generator comprises:

(a) an off-grid brightness value memory for storing the respective estimated off-grid brightness value derived by the response function compensator at each off-grid position received from the off-grid position generator;

(b) an on-grid resampler for deriving from the estimated off-grid brightness values in the off-grid brightness value memory respective resampled on-grid brightness values at the pixel positions of the pixel position array; and

(c) an output image memory for storing the respective resampled on-grid brightness values derived by the on-grid resampler as the pixel brightness values of the output image,

and wherein the on-grid resampler comprises:

(i) a pixel position generator for providing pixel positions of the pixel position array; and

(ii) an interpolator for receiving pixel positions provided by the pixel position generator and being responsive to a pixel position received from the pixel position generator for deriving from the estimated off-grid brightness values in the off-grid brightness value memory a respective resampled on-grid brightness value at the received pixel position.

99. The system of claim 96, wherein the accumulator of the off-grid estimator comprises an adder for adding the respective sensitivity level off-grid brightness values derived by the plurality of sensitivity level off-grid brightness value estimators for the corresponding sensitivity levels at each off-grid position received from the off-grid position generator to provide the combined sensitivity level off-grid brightness values at each off-grid position received from the off-grid position generator.

100. The system of claim 96, wherein the accumulator of the off-grid estimator comprises a weighting factor memory for storing a plurality of predetermined weighting factors each corresponding to a different one of the plurality of sensitivity levels of the light-sensing elements, a plurality of multipliers each for multiplying the sensitivity level off-grid brightness value corresponding to a respective one of the sensitivity levels at a received off-grid position by

the weighting factor corresponding to the respective one of the sensitivity levels to provide a weighted sensitivity level off-grid brightness value for the corresponding sensitivity level at the off-grid position received from the off-grid position generator, and an adder for summing the weighted sensitivity level off-grid brightness values at the received off-grid position provided by the plurality of multipliers to derive the combined sensitivity level off-grid brightness value at the off-grid positions received from the off-grid position generator.

101. The system of claim 100, wherein the array of light-sensing elements of the image sensor is a linear array and the pixel position array is a linear array having a multiplicity of pixel positions at respective regularly spaced pixel positions in a pixel row, and wherein the off-grid positions of the off-grid position array are each located between a respective adjacent pair of pixel positions of the pixel position array and the sensitivity level off-grid brightness values derived by the plurality of sensitivity level off-grid brightness value estimators for an off-grid position received from the off-grid position generator are respective captured image brightness values at a predefined number of pixel positions that are nearest neighbors to the received off-grid position, each one of the predefined number of nearest neighbor pixel positions corresponding to a different one of the plurality of sensitivity levels of the light-sensing elements.

102. The system of claim 101, wherein each one of the off-grid positions of the off-grid position array is located midway between a respective adjacent pair of pixel positions of the linear pixel position array and the predetermined sensitivity pattern of the light-sensing elements has a first and a second predetermined sensitivity level, and wherein the combined sensitivity level off-grid brightness value at an off-grid position x′ received from the off-grid position generator is expressed as

$$B(x') = W_1 I_c(x' - 0.5) + W_2 I_c(x' + 0.5),$$

where B(x′) is the combined sensitivity level off-grid brightness value at the received off-grid position x′, W_1 is the weighting factor for the sensitivity level corresponding to pixel position (x′ − 0.5), W_2 is the weighting factor for the sensitivity level corresponding to pixel position (x′ + 0.5), $I_c(x' - 0.5)$ is the captured image brightness value at pixel position (x′ − 0.5) and $I_c(x' + 0.5)$ is the captured image brightness value at pixel position (x′ + 0.5), and the combined response function of the light-sensing elements is expressed as

$$S(E) = W_1 P_1(E) + W_2 P_2(E),$$

where $P_1(E)$ is the radiometric response function of a light-sensing element having the sensitivity level corresponding to pixel position (x′ − 0.5) and $P_2(E)$ is the radiometric response function of a light-sensing element having the sensitivity level corresponding to pixel position (x′ + 0.5).

103. The system of claim 100, wherein the image sensor has a two-dimensional array of light-sensing elements and the multiplicity of pixel positions are located at respective

intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns defining a two-dimensional pixel position array, the pixel rows being orthogonal to the pixel columns, the multiplicity of off-grid positions are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each one of the intermediate rows being parallel to the pixel rows and extending between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

104. The system of claim 103, wherein the predetermined sensitivity pattern of the array of light-sensing elements corresponds to a pixel position array having repetitive disposed groups of four nearest neighbor pixel positions, where each one of the four nearest neighbor pixel positions in each group corresponds to a respective one of four predetermined sensitivity levels in a common predetermined positional order.

105. The system of claim 100, wherein the image sensor has a two-dimensional array of light-sensing elements and the multiplicity of pixel positions are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns defining a two-dimensional pixel position array, the pixel rows being orthogonal to the pixel columns, and wherein the multiplicity of off-grid positions are located at respective

intersections of a plurality of regularly spaced intermediate rows and the pixel columns, and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows being parallel to the pixel rows and extending between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

106. The system of claim 100, wherein the predetermined sensitivity pattern of the array of light-sensing elements has a first and a second predetermined sensitivity level, and adjacent pixel positions in each one of the pixel rows and adjacent pixel positions in each one of the pixel columns correspond to different ones of the predetermined first and second sensitivity levels.

107. The system of claim 100, wherein the array of light-sensing elements of the image sensor is a linear array and the multiplicity of pixel positions are located at respective regularly spaced pixel positions in a pixel row so as to form a linear captured image brightness value array, and wherein the linear array of light-sensing elements of the image sensor is adapted to be sequentially exposed to successive regularly spaced linear regions of the scene in multiple exposures, each one of the exposures producing a respective linear captured image brightness value array, the respective linear captured image brightness value arrays produced by the multiple exposures being concatenated to form a two-dimensional captured image brightness value array having respective captured image brightness values at pixel positions of a pixel

position array located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the multiplicity of off-grid positions are located at respective intersections of the pixel rows and a plurality of regularly spaced intermediate columns, each one of the intermediate columns being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

108. The system of claim 107, wherein the predetermined sensitivity pattern of the array of light-sensing elements has a first and a second predetermined sensitivity level, and wherein adjacent pixel positions in each pixel row correspond to different ones of the first and the second predetermined sensitivity levels and adjacent pixel positions in each pixel column correspond to the same one of the first and the second predetermined sensitivity levels.

109. The apparatus of claim 91 or 96, wherein each one of the sensitivity level off-grid brightness value estimators is responsive to an off-grid position received from the off-grid position generator and the data indicative of the sensitivity level corresponding to each one of the pixel positions from the sensitivity pattern memory for determining a pixel position corresponding to the same sensitivity level as the sensitivity level off-grid brightness value estimator and located nearest the received off-grid position, and for estimating a sensitivity level off-grid brightness value at the received off-grid position to be equal to the captured image

brightness value at the nearest pixel position corresponding to the same sensitivity level as the sensitivity level off-grid brightness value estimator.

110. The method of claim 92, wherein the interpolator is responsive to a pixel position received from the pixel position generator for computing a product of the estimated off-grid brightness values at a predetermined number of off-grid positions that are nearest neighbors to the received pixel position and an interpolation kernel having the same dimensions as the predetermined number of off-grid positions.

111. The apparatus of claim 92, wherein the pixel positions provided by the pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel columns being orthogonal to the pixel rows, and the off-grid positions provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each one of the intermediate rows being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each intermediate column being parallel to the pixel columns and extending medially between a respective adjacent pair of the pixel columns, and wherein the interpolator derives the interpolated on-grid brightness values at each one of the pixel positions (x,y) received from the pixel position generator using the relation

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x-1.5 + i, y-1.5 + j)\phi_{ij},$$

where x has values from 2.5 to xSize −2.5, y has values from 2.5 to ySize −2.5, I(x−2, y−2) is the interpolated on-grid brightness value at pixel position (x−2, y−2), B(x−1.5+i, y−1.5+j) is the off-grid brightness value at off-grid position (x−1.5+i, y−1.5+j), ϕ_{ij} is the value of a 4 × 4 cubic interpolation kernel ϕ at indices i and j, indices i and j each has values from 0 to 3, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is the dimension of the captured image in the direction of the pixel columns.

112. The apparatus of claim 98, wherein the pixel positions provided by the pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and the off-grid positions provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each one of the intermediate rows being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending medially between a respective adjacent pair of the pixel columns, and wherein the interpolator derives the

resampled on-grid brightness values at each one of the pixel positions (x,y) received from the pixel position generator by the relation

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x-1.5 + i,\ y-1.5 + j)\phi_{ij},$$

where x has values from 2.5 to xSize−2.5, y has values from 2.5 to ySize−2.5, I(x−2, y−2) is the resampled on-grid brightness value at pixel position (x−2, y−2), B(x−1.5+i,y−1.5+j) is the off-grid brightness value at off-grid position (x−1.5+i, y−1.5+j), ϕ_{ij} is the value of a 4 × 4 cubic interpolation kernel ϕ at indices i and j, the indices i and j each have values from 0 to 3, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is the dimension of the captured image in the direction of the pixel columns.

113. The apparatus of claim 92, wherein the pixel positions provided by the pixel position generator are located at respective intersections of a plurality of regularly spaced pixel columns and a pluraity of regularly spaced pixel rows, the pixel rows being orthogonal to the pixel columns, and the off-grid positions provided by the off-grid generator are located at respective intersections of a plurality of regularly spaced intermediate rows and the pixel columns and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each one of the

intermediate columns being parallel to the pixel columns and extending medially between a respective adjacent pair of the pixel columns, and wherein the interpolator derives the interpolated on-grid brightness values at each one of the pixel positions (x,y) received from the pixel position generator using the relation

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x+0.5i-0.5j,\ y-1.5+0.5i+0.5j)\phi_{ij},$$

where x has values from 2.5 to xSize −2.5, y has values from 2.5 to ySize −2.5, I(x−2, y−2) is the interpolated on-grid brightness value at pixel position (x−2, y−2), B(x+0.5i−0.5j, y−1.5+0.5i+0.5j) is the off-grid brightness value at off-grid position (x+0.5i−0.5j, y−1.5+0.5i+0.5j), ϕ_{ij} is the value of a 4 × 4 cubic interpolation kernel ϕ at indices i and j, indices i and j each have values from 0 to 3, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is the dimension of the captured image in the direction of the pixel columns.

114. The apparatus of claim 98, wherein the pixel positions provided by the pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and the off-grid positions provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and the pixel

columns and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each one of the intermediate columns being parallel to the pixel columns and extending medially between a respective adjacent pair of the pixel columns, and wherein the interpolator derives the resampled on-grid brightness values at each one of the pixel positions (x,y) received from the pixel position generator using the relation

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x+0.5i-0.5j,\ y-1.5+0.5i+0.5j)\phi_{ij},$$

where x has values from 2.5 to xSize−2.5, y has values from 2.5 to ySize−2.5, I(x−2,y−2) is the resampled on-grid brightness value at pixel position (x−2,y−2), B(x+0.5i−0.5j, y−1.5+0.5i+0.5j) is the off-grid brightness value at the off-grid position (x+0.5i−0.5j, y−1.5+0.5i+0.5j), ϕ_{ij} is the value of a 4 × 4 cubic interpolation kernel ϕ at indices i and j, indices i and j each have values from 0 to 3, xSize is the dimension of the captured image in the direction of the pixel rows, and ySize is dimension of the captured image in the direction of the pixel columns.

115. The method of claim 111 or 112, wherein the 4 × 4 cubic interpolation kernel ϕ has the form:

0.043	-0.661	-0.661	0.043
-0.661	10.28	10.28	-0.661
-0.661	10.28	10.28	-0.661
0.043	-0.661	-0.661	0.043

j

i

.

116. The system of claim 98, wherein the pixel positions provided by the pixel position generator are located at respective regularly spaced pixel positions in a pixel row defining a linear pixel position array and the off-grid positions provided by the off-grid position generator are each located midway between a respective adjacent pair of pixel positions of the pixel position row, and wherein the interpolator derives the resampled on-grid brightness values at each one of the pixel positions x received from the pixel position generator using the relation

$$I_o(x - 3) = \sum_{k=-1.5}^{k=1.5} B(x + k)\psi(k),$$

where x has values from 3.5 to xSize−3.5, $I_o(x - 3)$ is the resampled on-grid brightness value at pixel position (x − 3), B(x + k) is the estimated off-grid brightness value at off-grid position (x + k), k is a position of a 4 × 1 cubic interpolation kernel ψ, $\psi(k)$ is the value of the cubic interpolation kernel ψ at position k, the position k has values from −1.5 to 1.5, and xSize is the dimension of the captured line image.

117. The system of claim 116, wherein the 4 × 1 cubic interpolation kernel x has the form:

-0.96	13.44	13.44	-0.96

$\vec{k}$.

118. The apparatus of claim 77, wherein the image sensor is an integrated circuit charge coupled device having an array of photodiodes in spaced orthogonal rows and columns, each one of the photodiodes having a light-sensing surface adapted to be exposed to incident light and being operatively biased to store photogenerated charge therein, the charge coupled device having respective integrated lenses formed over the photosensitive surfaces of predetermined ones of the photodiodes, each integrated lens concentrating the incident light onto the respective light-sensing surface, whereby the sensitivity level of each one of the photodiodes is determined by whether or not an integrated lens is formed over the light-sensing surface thereof.

119. The apparatus of claim 77, wherein the image sensor is an integrated circuit charge coupled device having an array of photodiodes arranged in spaced orthogonal rows and columns, each one of the photodiodes having a light-sensing surface adapted to be exposed to incident light and being operatively biased to store photogenerated charge therein, each one of the photodiodes having an integrated light filter formed above the light-sensing surface thereof, the transparency of each integrated light filter being fixed during fabrication of the charge coupled

device, whereby the sensitivity level of each one of the photodiodes in the array is determined by the transparency of the integrated light filter above the light-sensing surface thereof.

120. The system of claim 77, wherein the image sensor is an integrated circuit charge coupled device having an array of photodiodes arranged in spaced orthogonal rows and columns, each one of the photodiodes having a light-sensing surface adapted to be exposed to incident light and being operatively biased to store photogenerated charge therein, the charge coupled device being formed with an opaque layer overlying the array of photodiodes with a respective aperture formed in the opaque layer above the light-sensing surface of each one of the photodiodes, the respective size of the aperture above the light-sensing surface of each one of the photodiodes being fixed during fabrication of the charge coupled device, whereby the sensitivity level of each one of the photodiodes in the array is determined by the size of the aperture above the light-sensing surface thereof.

121. The system of claim 77, wherein the image sensor is an integrated circuit charge coupled device having a multiplicity of photodiodes in an array of spaced orthogonal rows and columns, each one of the photodiodes having a light-sensing surface adapted to be exposed to incident light and being operatively biased to store photogenerated charge therein, the charge coupled device having an interline structure in which the columns of photodiodes are each disposed adjacent a corresponding vertical shift register, each photodiode having an associated

transfer gate electrode for controlling the transfer of stored photogenerated charge from the photodiode to the corresponding vertical shift register, the stored photogenerated charge in each one of the photodiodes being operatively periodically removed by the application of a periodic reset pulse to the device, the photogenerated charge stored in each one of the photodiodes being operatively transferred to a respective stage of the corresponding vertical shift register by the application of a transfer trigger pulse to the associated transfer gate electrode and being accumulated therein for an exposure interval, the transfer trigger pulse being applied immediately preceding a reset pulse, the respective transfer trigger pulses being operatively applied to the transfer gate electrodes associated with the photodiodes in the array at predetermined frequencies, whereby the sensitivity level of each one of the photodiodes in the array is determined by the frequency of transfer trigger pulses applied to the transfer gate electrode associated therewith.

122. The system of claim 77, wherein the off-grid estimator comprises:

(a) a pixel position generator for providing the pixel positions of the pixel position array;

(b) a sensitivity pattern memory for storing the sensitivity level corresponding to each one of the pixel positions;

(c) a response function compensator receiving pixel positions of the pixel position array from the pixel position generator, data indicative of the sensitivity levels corresponding to the received pixel positions from the sensitivity pattern memory and captured image brightness

values at the received pixel positions from the captured image memory, and being responsive to a pixel position received from the pixel position generator and data indicative of the sensitivity level corresponding to the received pixel position for retrieving from the captured image memory the captured image brightness value at the received pixel position and for compensating the retrieved captured imaged brightness value at the received pixel positions by the inverse of a response function of a light-sensing element having the sensitivity level corresponding to the received pixel position to provide a respective compensated brightness value at the pixel position received from the pixel position generator;

(d) a compensated on-grid brightness value memory for storing respective compensated captured image brightness values derived by the response function compensator;

(e) an off-grid position generator for providing the off-grid positions of the off-grid position array;

(f) a pseudoinverse estimator receiving off-grid positions from the off-grid position generator and being responsive to an off-grid position received from the off-grid position generator for deriving from the compensated captured image brightness values in the compensated on-grid brightness value memory a respective estimated off-grid brightness value at the off-grid positions received from the off-grid position generator.

123. The system of claim 122, wherein the output image generator comprises

(i) an off-grid brightness value memory for storing the respective estimated off-grid brightness values derived by the pseudoinverse estimator;

(ii) an on-grid resampler for deriving from the estimated off-grid brightness values in the off-grid brightness value memory respective on-grid resampled brightness values at the pixel positions of the pixel position array; and

(iii) an output image memory for storing the respective resampled on-grid brightness values derived by the on-grid resampler as pixel brightness values of the output image, and wherein the on-grid resampler comprises:

(1) a second pixel position generator for providing the pixel positions of the pixel position array; and

(2) an interpolator receiving pixel positions from the pixel position generator and being responsive to a pixel position received from the second pixel position generator for deriving from the estimated off-grid brightness values in the off-grid brightness value memory the resampled on-grid brightness value at the pixel position received from the second pixel position generator.

124. The system of claim 122, wherein the response function compensator comprises a lookup table memory storing separate lookup table data representing the inverse of respective response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and a mapper receiving from the captured image memory the captured image brightness

value at the pixel position received from the first pixel position generator for deriving therefrom a respective index for the lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the received pixel position, and providing a compensated on-grid brightness value corresponding to the index to the compensated on-grid brightness value memory.

125. The system of claim 122, wherein the pseudoinverse estimator comprises means responsive to an off-grid positions received from the off-grid position generator for retrieving from the compensated on-grid brightness value memory respective compensated on-grid brightness values at a predetermined number of pixel positions that are nearest neighbors to the received off-grid position, a comparator for comparing each one of the respective compensated on-grid brightness values at the nearest neighbor pixel positions to a predetermined low threshold value and a predetermined high threshold value, an adder means for computing a sum of compensated on-grid brightness values at the nearest neighbor pixel positions that are greater than the predetermined low threshold value and less than the predetermined high threshold value, and a divider for deriving the estimated off-grid brightness value at the received off-grid position by dividing the sum computed by the adder by the number of compensated on-grid brightness values included in the sum.

126. The system according to claim 122, wherein the pixel positions provided by the pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and the off-grid positions provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each one of the intermediate rows being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each intermediate column being parallel to the pixel columns and extending medially between a respective adjacent pair of pixel columns, and wherein the off-grid positions provided by the off-grid position generator have coordinates (x',y') where x' has values from 1 to $xSize-1$ and y' has values from 1 to $ySize-1$, xSize being the dimension of the captured image in the direction of the pixel rows and ySize being the dimension of the captured image in the direction of the pixel columns.

127. The system of claim 126, wherein the predetermined sensitivity pattern of the array of light-sensing elements corresponds to a pixel position array having repetitively disposed groups of four nearest neighbor pixel positions, where each of the four nearest neighbor pixel positions in each group corresponds to a respective one of four predetermined sensitivity levels in a common predetermined positional order.

128. The system of claim 126, wherein the pseudoinverse estimator for estimating the respective brightness value at an off-grid position (x′,y′) received from the off-grid position generator comprises:

(i) a memory for storing a 4 × 4 cubic interpolator kernel ϕ;

(ii) a comparator for comparing the compensated on-grid brightness value at each one of sixteen pixel positions (u,v) that are nearest neighbors to the received off-grid position (x′,y′) with a predetermined low threshold value and a predetermined high threshold value;

(iii) first computing means for calculating the indices i and j of the 4 × 4 cubic interpolation kernel ϕ using the relations $i = x' - u - 1.5$ and $j = y' - v - 1.5$ for each one of the sixteen nearest neighbor pixel positions (u,v) having a compensated on-grid brightness value I(u,v) that is greater than the predetermined low threshold value and less than the predetermined high threshold value, where u has values from $x' - 1.5$ to $x' + 1.5$ and v has values from $y' - 1.5$ to $y' + 1.5$;

(iv) second computing means for calculating the quantity

$$\phi_{ij}^2 \frac{\phi_{ji} \, I(u,v)}{\sum_{ab} \phi_{ab}^2}$$

for each compensated on-grid brightness value I(u,v) at the sixteen nearest neighbor pixel positions (u,v) that is greater than the predetermined threshold value and less than the

predetermined threshold value using the indices i and j calculated by the first computing means, where ϕ_{mn} is the value of the 4×4 interpolating kernel ϕ at indices m and n;

(v) third computing means for calculating the quantities ϕ_{ij}^2, for values of i and j calculated by the first computing means;

(vi) first adder for adding the quantities

$$\phi_{ij}^2 \frac{\phi_{ji}\, I(u,v)}{\sum_{ab} \phi_{ab}^2}$$

calculated by the second computing means to derive a first sum s;

(vii) second adder for adding the quantities ϕ_{ij}^2 calculated by the third computing means to derive a second sum w; and

(viii) a divider for deriving the estimated off-grid brightness value at the received off-grid position (x′,y′) by dividing the first sum s by the second sum w.

129. The system according to claim 122, wherein the pixel positions provided by the pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, and the off-grid positions provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and the pixel columns, and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows

being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each intermediate column being parallel to the pixel columns and extending medially between a respective adjacent pair of the pixel columns, the off-grid positions provided by the off-grid position generator having coordinates $(x'y')$ where x' has values from 1 to xSize$-$1 and y' has values from 0.5 to ySize$-$0.5 for off-grid positions located at respective intersections of the pixel rows and the intermediate columns, and where x' has values from 0.5 to ySize$-$0.5 and y' has values from 1 to ySize$-$1 for off-grid positions located at respective intersections of the pixel columns and the intermediate rows, xSize being the dimension of the captured image in the direction of the pixel rows and ySize being the dimension of the captured image in the direction of the pixel columns.

130. The system of claim 129, wherein the predetermined sensitivity pattern of the array of light-sensing elements has first and second predetermined sensitivity levels, and adjacent pixel positions in each pixel row and adjacent pixel positions in each pixel column correspond to different ones of the first and second predetermined sensitivity levels.

131. The system of claim 129, wherein the pseudoinverse estimator for estimating the respective off-grid brightness value at an off-grid position (x',y') received from the off-grid position generator comprises:

(i) a memory for storing a 4×4 cubic interpolation kernel ϕ;

(ii) first computing means responsive to an off-grid position (x',y') received from the off-grid position generator for computing coordinates (u,v) using the relations $u=x'+0.5i-0.5j$ and $v=y'-1.5+0.5i+0.5j$, where i and j are indices of the 4×4 cubic interpolation kernel ϕ, and each one of the indices i and j has values from 0 to 3;

(iii) means responsive to each pair of coordinates (u,v) computed by the first computing means for determining whether the coordinates (u,v) are those of a pixel position;

(iv) a comparator responsive to the coordinates (u,v) being coordinates of a pixel position for comparing the compensated on-grid brightness value I(u,v) at the pixel position (u,v) with a predetermined low threshold value and a predetermined high threshold value;

(v) second computing means responsive to the coordinates (u,v) being the coordinates of a pixel position and the compensated on-grid brightness value I(u,v) at the pixel position (u,v) being greater than a predetermined low threshold value and less than a predetermined high threshold value for calculating the quantity

$$\phi_{ij}^2 \frac{\phi_{ji} \, I(u,v)}{\sum_{ab} \phi_{ab}^2},$$

where the values of i and j are those used by the first computing means to calculate the coordinate (u,v), and ϕ_{mn} is the value of the 4×4 cubic interpolation kernel ϕ at indices m and n;

(vi) third computing means for calculating the quantity ϕ_{ij}^2 for values of i and j used by the first computing means to calculate pixel position coordinates (u,v) at which the compensated

on-grid brightness value I(u,v) is greater than the predetermined low threshold value and less than the predetermined high threshold value;

(vii) a first adder for adding the quantities

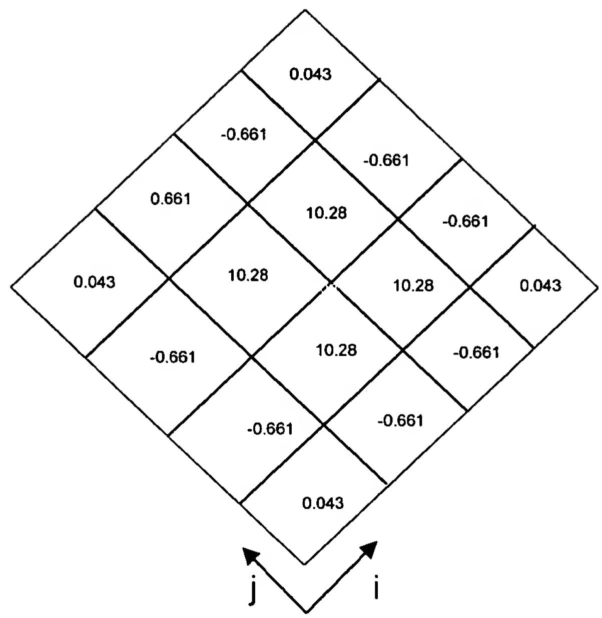
$$\phi_{ij}^{2}\,\frac{\phi_{ji}\; I(u,v)}{\sum_{ab}\;\phi_{ab}^{2}}$$

calculated by the second computing means to derive a first sum s;

(viii) a second adder for adding the quantities ϕ_{ij}^{2} calculated by the third computing means to derive a second sum w; and

(ix) a divider for deriving the estimated off-grid brightness value at the off-grid position (x′,y′) received from the off-grid position generator by dividing the first sum s by the second sum w.

132. The system of claim 131, wherein the 4 × 4 cubic interpolation kernel ϕ has the form:



133. The system of claim 122, wherein the pixel positions provided by the pixel position generator are located at respective regularly spaced pixel positions in a linear pixel position array and the off-grid positions provided by the off-grid position generator are each located midway between a respective adjacent pair of pixel positions of the linear pixel position array, and wherein the predetermined sensitivity pattern of the light-sensing elements has a first and a second predetermined sensitivity level, and adjacent pixel positions of the linear pixel position array correspond to different ones of the first and second predetermined sensitivity levels.

134. The system of claim 133, wherein the pixel positions provided by the pixel position generator has values from 0.5 to xSize−0.5, where xSize is the dimension of the captured line image, and the off-grid positions provided by the off-grid position generator have values from 2 to xSize−2.

135. The system of claim 134, wherein the pseudoinverse estimator for estimating the respective brightness values at an off-grid position x′ received from the off-grid position generator comprises:

(i) a memory for storing a 4 × 1 Gaussian interpolation kernel G;

(ii) a comparator for comparing the compensated on-grid brightness value I(k) at each one of four pixel positions k that are nearest neighbors to the received off-grid position x′ with a predetermined low threshold value and a predetermined high threshold value, where k has values from x′−1.5 to x′+1.5;

(iii) first computing means for calculating the quantity I(k)G(k−x′) for each one of the compensated on-grid brightness values I(k) at the four nearest neighbor pixel positions k that is greater than the predetermined low threshold value and less than the predetermined high theshold value, where G(k−x′) is the value of the Gaussian interpolation kernel G at position (k−x′);

(iv) a first adder for adding the quantities I(k)G(k−x′) for all values of I(k) greater than the predetermined low threshold value and less than the predetermined high threshold value to derive a first sum p;

(v) a second adder for adding the Gaussian interpolation kernel values G(k−x′) for all values of k where I(k) is greater than the predetermined low threshold value and less than the predetermined high threshold value to derive a second sum q; and

(vi) a divider for deriving the estimated off-grid brightness value B(x′) at the off-grid position x′ received from the off-grid position generator.

136. The apparatus of claim 125, 128, 131 or 135, wherein the predetermined low threshold value is the noise level of a light-sensing element having a sensitivity level corresponding to the pixel position of the compensated on-grid brightness value being compared therewith compensated by the inverse of the response function of the light-sensing element, and the predetermined high threshold value is the saturation or near saturation brightness value of a light-sensing element having the sensitivity level corresponding to the pixel position of the compensated on-grid brightness value being compared therewith.

137. The apparatus of claim 123, wherein the pixel positions of the pixel position array provided by the second pixel position generator are located at respective regularly spaced pixel positions of a linear pixel position array, and the off-grid positions of the off-grid position array provided by the off-grid position generator are each located between a respective adjacent pair of pixel positions of the linear pixel position array.

138. The apparatus of claim 123, wherein the pixel positions of the pixel position array provided by the second pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the off-grid positions of the off-grid position array provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and a plurality of regularly spaced intermediate columns, each intermediate row being parallel to the pixel rows and extending between a respective adjacent pair of the pixel rows and each intermediate column being parallel to the pixel columns and extending between a respective adjacent pair of the pixel columns.

139. The apparatus of claim 123, wherein the pixel positions of the pixel position array provided by the second pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the off-grid positions of the off-grid position array provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate pixel columns being parallel to the pixel columns and extending between a respective adjacent pair of pixel columns.

140. The apparatus of claim 137, 138 or 139, wherein the interpolator includes means for shifting the off-grid position array to coincide with the pixel position array, whereby the resampled on-grid brightness value at each pixel position of the pixel position array is equal to the estimated off-grid brightness value at a coincident off-grid position of the shifted off-grid position array.

141. The apparatus of claim 138, wherein the interpolator derives a respective resampled on-grid brightness value at a pixel position received from the second pixel position generator by computing the product of respective estimated off-grid brightness values at a predetermined number of off-grid positions that are nearest neighbors to the received pixel position and an interpolation kernel having the same dimensions as the predetermined number of off-grid positions.

142. The apparatus of claim 141, wherein the plurality of intermediate rows each extend medially between a respective adjacent pair of pixel rows and the plurality of regularly spaced intermediate columns each extend medially between a respective adjacent pair of pixel columns, and wherein the pixel positions provided by the second pixel position generator have coordinates (x,y) where x has values from 2.5 to xSize−2.5 and, y has values from 2.5 to ySize−2.5, xSize is the dimension of the captured image in the direction of the pixel rows and ySize is the dimension of the captured image in the direction of the pixel columns.

143. The apparatus of claim 142, wherein the interpolator is responsive to a pixel position (x,y) received from the second pixel position generator for deriving a respective resampled on-grid brightness value in accordance with the relation

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x-1.5 + i, y-1.5 + j)\phi_{ij},$$

where I(x−2, y−2) is the resampled on-grid brightness value at pixel position (x−2, y−2), B(x−1.5+i, y−1.5+j) is the estimated off-grid brightness value at off-grid position (x−1.5+i, y−1.5+j), ϕ_{ij} is the value of a 4 × 4 cubic interpolation kernel ϕ at indices i and j, and indices i and j each has values from 0 to 3.

144. The system of claim 123, wherein the pixel positions provided by the second pixel position generator are located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the off-grid positions provided by the off-grid position generator are located at respective intersections of a plurality of regularly spaced intermediate rows and the pixel columns, and at respective intersections of a plurality of regularly spaced intermediate columns and the pixel rows, each one of the intermediate rows being parallel to the pixel rows and extending medially between a respective adjacent pair of the pixel rows, each intermediate

column being parallel to the pixel columns and extending medially between a respective adjacent pair of the pixel columns, the pixel positions provided by the second pixel position generator having coordinates (x,y) where x has values from 2.5 to xSize−2.5, y has values from 2.5 to ySize−2.5, xSize is the dimension of the captured image in the direction of the pixel rows and ySize is the dimension of the captured image in the direction of the pixel columns.

145. The system of claim 144, wherein the interpolator is responsive to a pixel position received from the second pixel position generator for deriving a respective resampled on-grid brightness value in accordance with the relation

$$I(x-2,y-2) = \sum_{i=o}^{3} \sum_{j=0}^{3} B(x+0.5i-0.5j,\ y-1.5+0.5i+0.5j)\phi_{ij},$$

where I(x−2,y−2) is the resampled brightness value at pixel position (x−2, y−2), B(x+0.5i−0.5j, y−1.5+0.5i+0.5j) is the off-grid brightness value at off-grid position (x+0.5i−0.5j, y−1.5+0.5i+0.5j), ϕ_{ij} is the value of a 4 × 4 cubic interpolation kernel ϕ at indices i and j, and the indices i and j each have values from 0 to 3.

146. The method of claim 128 or 143, wherein the 4 × 4 cubic interpolation kernel ϕ has the form:

	0.043	-0.661	-0.661	0.043
	-0.661	10.28	10.28	-0.661
	-0.661	10.28	10.28	-0.661
j ↑	0.043	-0.661	-0.661	0.043
	i →			

147. The apparatus of claim 141, wherein the interpolation kernel is a 2-dimensional Gaussian kernel.

148. The system of claim 147, wherein the 2-dimensional Gaussian kernel has the form:

	0.0037	0.0101	0.0166	0.0166	0.0101	0.0037
	0.0101	0.0275	0.0452	0.0452	0.0275	0.0101
	0.0166	0.0452	0.0743	0.0743	0.0452	0.0166
	0.0166	0.0452	0.0743	0.0743	0.0452	0.0166
	0.0101	0.0275	0.0452	0.0452	0.0275	0.0101
j ↑	0.0037	0.0101	0.0166	0.0166	0.0101	0.0037
	i →					

149. The system of claim 141, wherein the interpolation kernel is a bi-cubic B-spline interpolation filter kernel.

150. The system of claim 149, wherein the bi-cubic B-spline interpolation filter kernel has the form:

0.0043	0.0100	0.0100	0.0043
0.0100	0.2296	0.2296	0.0100
0.0100	0.2296	0.2296	0.0100
0.0043	0.0100	0.0100	0.0043

.

151. The apparatus of claim 141, wherein the interpolation kernel is a bi-linear interpolation filter kernel.

152. The system of claim 151, wherein the bi-linear interpolation kernel has the form:

0.5	0.5
0.5	0.5

.

153. The system of claim 137, wherein the off-grid positions provided by the off-grid position generator are each located midway between a respective adjacent pair of pixel positions of the linear pixel position array, the pixel positions provided by the second pixel position

generator having coordinate x, where x has values from 3.5 to xSize−3.5 and xSize is the dimension of the captured line image.

154. The system of claim 153, wherein the interpolator is responsive to a pixel position received from the second pixel position generator for deriving a respective resampled on-grid position brightness value in accordance with the relation

$$I_o(x-3) = \sum_{k=-1.5}^{k=1.5} B(x+k)\psi(k),$$

where $I_o(x-3)$ is the resampled on-grid brightness value at pixel position (x−3), B(x+k) is the estimated off-grid brightness value at off-grid position (x+k), k is a position of a 4 × 1 cubic interpolation kernel ψ, ψ(k) is the value of the cubic interpolation kernel ψ at position k, and the position k has values from −1.5 to 1.5.

155. The system of claim 154, wherein the 4 × 1 cubic interpolation kernel ψ has the form:

−0.96	13.44	13.44	−0.96

156. A system for obtaining a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor adapted to be exposed to incident light from the scene for capturing an image thereof comprising:

(a) an image sensor having a multiplicity of light-sensing elements in an array, each one of the light-sensing elements having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and having a response function, each one of the light-sensing elements in response to incident light from the scene producing a captured image brightness value at a corresponding one of a multiplicity of pixel positions of a pixel position array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels of the light-sensing elements;

(b) a captured image memory for storing respective captured image brightness values produced by the light-sensing elements at pixel positions of the pixel position array;

(c) a pixel position generator for providing the pixel positions of the pixel position array;

(d) an on-grid brightness value generator receiving the pixel positions from the pixel position generator and being responsive to a pixel position received from the pixel position generator for deriving from the captured image brightness values in the captured image memory a respective output image brightness value at the received pixel position, the respective output

image brightness value being derived from a corresponding plurality of captured image brightness values; and

(e) an output image memory for storing the respective output image brightness value at each pixel position received from the pixel position generator derived by the on-grid brightness value generator.

157. The system of claim 156, wherein the array of light-sensing elements of the image sensor is a two-dimensional array and the pixel position array is a linear array having regularly spaced pixel positions in a linear pixel position row.

158. The system of claim 156, wherein the array of light-sensing elements of the image sensor is a two-dimensional array and the pixel position array is a two-dimensional array having pixel positions located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the pixel positions provided by the pixel position generator have coordinates (x,y), where x has values from 2.5 to xSize−2.5, y has values from 2.5 to ySize−2.5, and xSize and ySize are the dimensions of the captured image in the directions of the pixel rows and the pixel columns, respectively.

159. The system of claim 158, wherein the on-grid brightness value generator is responsive to a pixel position (x,y) received from the pixel position generator for deriving from the captured image brightness values in the captured image memory a respective output image brightness value at the received pixel position in accordance with the relation

$$I_o(x-2,y-2) = \sum_{i=o}^{4} \sum_{j=0}^{4} I_c(x-2 + i, y-2 + j)\phi_{ij},$$

where $I_c(x - 2 + i, y - 2 + j)$ is the captured image brightness value at pixel position $(x - 2 + i, y - 2 + j)$, ϕ_{ij} is the value of an on-grid interpolation filter kernel ϕ at indices i and j, indices i and j each have values from 0 to 4, and $I_o(x - 2, y -2)$ is the output image brightness value at pixel position $(x - 2, y - 2)$.

160. A system for obtaining a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor adapted to be exposed to incident light from the scene for capturing an image thereof comprising:

(a) an image sensor having a multiplicity of light-sensing elements in an array, each one of the light-sensing elements having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and having a response function, each light-sensing element in response to incident light from the scene producing a captured image brightness value at a corresponding one of a

multiplicity of pixel positions of a pixel position array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels of the light-sensing elements;

(b) a captured image memory for storing the captured image brightness values produced by the light-sensing elements at pixel positions of the pixel position array;

(c) a pixel position generator for providing the pixel positions of the pixel position array;

(d) an on-grid brightness value generator receiving pixel positions from the pixel position generator and being responsive to a pixel position received from the pixel position generator for deriving from the captured image brightness values in the captured image memory a respective on-grid brightness value at the received pixel position, the respective on-grid brightness value being derived from a corresponding plurality of captured image brightness values;

(e) a response function compensator for compensating the respective on-grid brightness value at each received pixel position derived by the on-grid brightness value generator by the inverse of a combined response function of the light-sensing elements to provide a respective output image brightness value at each pixel position received from the pixel position generator, the combined response function being the sum of weighted response functions of light-sensing elements having different ones of the plurality of sensitivity levels, each one of the weighted response functions being a response function of a light-sensing element having a respective one of the plurality of sensitivity levels multiplied by a predetermined weighting factor for the respective one of the plurality of sensitivity levels; and

(f) an output image memory for storing the respective output image brightness value at each received pixel positions provided by the response function compensator.

161. The system of claim 160, wherein the response function compensator comprises a lookup table memory storing data representing the inverse of the combined response function of the light-sensing elements, and a mapper receiving on-grid brightness values from the on-grid brightness value generator and being responsive to an on-grid brightness value at a pixel position received from the pixel position generator for deriving a respective index for the lookup table memory and providing a data value in the lookup table memory corresponding to the respective index, the data value being the output image brightness value at the pixel position received from the pixel position generator.

162. The system of claim 160, wherein the array of light-sensing elements of the image sensor is a two-dimensional array for capturing two-dimensional images, and the pixel position array is a two-dimensional array having pixel positions located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns, and wherein the pixel positions provided by the pixel position generator having coordinates (x,y), where x has values from 2.5 to xSize−2.5, y has values from 2.5 to ySize−2.5, and xSize and ySize are the dimensions of the captured image in the directions of the pixel rows and the pixel columns, respectively.

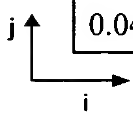
163. The system of claim 162, wherein the on-grid brightness value generator is responsive to a pixel position received from the pixel position generator for deriving from the captured image brightness values in the captured image memory a respective on-grid brightness value at the received pixel position in accordance with the relation

$$I(x-2,y-2) = \sum_{i=o}^{4} \sum_{j=0}^{4} I_c(x-2 + i, y-2 + j)\phi_{ij},$$

where $I_c(x - 2 + i, y - 2 + j)$ is the captured image brightness value at pixel position $(x - 2 + i, y - 2 + j)$, ϕ_{ij} is the value of a on-grid interpolation filter kernel ϕ at indices i and j, the indices i and j each have values from 0 to 4, and $I(x - 2, y -2)$ is the on-grid brightness value at pixel position $(x - 2, y - 2)$.

164. The method of claim 159 or 163, wherein the on-grid interpolation filter kernel ϕ has the form:

0.043	-0.618	-1.322	-0.618	0.043
-0.618	9.001	19.238	9.001	-0.618
-1.322	19.238	41.12	19.238	-1.322
-0.618	9.001	19.238	9.001	-0.618
0.043	-0.618	-1.322	-0.618	0.043



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165. The system of claim 158, wherein the array of light-sensing elements of the image sensor is a linear array for capturing a line image, and the pixel position array is a linear array having regularly spaced pixel positions in a linear pixel row.

166. A system for obtaining a relatively high dynamic range image of a scene using a relatively low dynamic range image sensor adapted to be exposed to incident light from the scene for capturing an image thereof comprising:

(a) an image sensor having a multiplicity of light-sensing elements in an array, each one of the light-sensing elements having a particular one of a plurality of sensitivity levels to incident light in accordance with a predetermined sensitivity pattern for the array of light-sensing elements and having a respective response function, each light-sensing element in response to incident light from the scene producing a captured image brightness value at a corresponding one

of a multiplicity of pixel positions of a pixel position array, whereby each one of the multiplicity of pixel positions corresponds to a particular one of the plurality of sensitivity levels of the light-sensing elements;

(b) a captured image memory for storing the captured image brightness values produced by the light-sensing elements at pixel positions of the pixel position array;

(c) a first pixel position generator for providing the pixel positions of the pixel position array;

(d) a sensitivity pattern memory for storing data indicative of the sensitivity level corresponding to each one of the first pixel positions of the pixel position array;

(e) a response function compensator receiving pixel positions from the first pixel position generator, data indicative of the sensitivity levels corresponding to the received pixel positions from the sensitivity pattern memory and captured image brightness values at the received pixel positions from the captured image memory, and being responsive to a pixel position received from the first pixel position generator and data indicative of the sensitivity level corresponding to the received pixel position for retrieving from the captured image memory the captured image brightness value at the received pixel position and for compensating the retrieved captured image brightness value at the received pixel position by the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the received pixel position to provide a respective compensated brightness value at the pixel position received from the first pixel position generator;

(f) a compensated on-grid brightness value memory for storing respective compensated captured image values at the pixel positions received from the first pixel position generator;

(g) a second pixel position generator for providing the pixel positions of the pixel position array;

(h) an on-grid brightness value generator receiving pixel positions from the second pixel position generator and being responsive to each pixel position received from the second pixel position generator for deriving from the captured image brightness values in the captured image memory a respective output image brightness value at each received pixel position; and

(i) an output image memory for storing the respective output image brightness value at each pixel position received from the second pixel position generator.

167. The system of claim 166, wherein the response function compensator comprises a lookup table memory storing separate lookup table data representing the inverse of respective response functions of light-sensing elements having different ones of the plurality of sensitivity levels, and a mapper receiving captured image brightness values from the captured image memory and being responsive to a captured image brightness value at a pixel position received from the first pixel position generator for deriving a respective index for the lookup table memory, and retrieving therefrom a compensated on-grid brightness value corresponding to the respective index from lookup table data representing the inverse of the response function of a light-sensing element having the sensitivity level corresponding to the received pixel position,

the retrieved compensated on-grid brightness value being provided to the compensated on-grid brightness value memory.

168. The system of claim 166, wherein the array of light-sensing elements of the image sensor is a two-dimensional array, and the pixel position array is a two-dimensional array having pixel positions located at respective intersections of a plurality of regularly spaced pixel rows and a plurality of regularly spaced pixel columns, the pixel rows being orthogonal to the pixel columns.

169. The system of claim 166, wherein the array of light-sensing elements of the image sensor is a linear array for capturing a line image and the pixel position array is a linear array having respective regularly spaced pixel positions of a linear pixel row, and wherein the pixel positions provided by the pixel position generator have coordinates x, where x has values from 2.5 to xSize−2.5 and xSize is the dimension of the captured line image.

170. The system of claim 169, wherein the on-grid brightness value generator is responsive to a pixel position x received from the second pixel position generator for deriving from the captured image brightness values in the captured image memory a respective output image brightness value at the received pixel position, the on-grid brightness value generator comprising:

(i) a memory for storing a 5 × 1 Gaussian interpolation filter kernel G;

(ii) a comparator for comparing each one of five compensated on-grid brightness values I(k) at pixel positions k having values from x−2 to x+2 with a predetermined low threshold value and a predetermined high threshold value;

(iii) a multiplier for calculating a quantity I(k)G(k−x) for each value of k at which I(k) is greater than the predetermined low threshold value and less than the predetermined high threshold value, where G(k−x) is the value of the Gaussian interpolation kernel G at position (k−x);

(iv) a first adder for adding the quantities I(k)G(k−x) calculated by the multiplier for each value of k where I(k) is greater than the predetermined low threshold value and less than the predetermined high threshold value to derive a first sum p;

(v) a second adder for adding the values G(k−x) of the Gaussian interpolation kernel in the memory for each value of k where I(k) is greater than the predetermined low threshold value and less than the predetermined high threshold value to derive a second sum q; and

(vi) a divider for deriving a respective output image brightness value $I_o(x)$ at the position x received from the second pixel position generator by dividing the sum p by the sum q.

171. The system of claim 170, wherein the predetermined low threshold value is the noise level of a light-sensing element having the sensitivity level corresponding to the pixel position of the compensated on-grid brightness value being compared therewith compensated by

the inverse of the response function of the light-sensing element, and the predetermined high threshold value is the saturation or near saturation brightness value of a light-sensing element having the sensitivity level corresponding to the pixel position of the compensated on-grid brightness value being compared therewith.

172. The system of claim 170, wherein the 5×1 Gaussian interpolator filter kernel has the form:

0.1	3.6	10.0	3.6	0.1

$\vec{k}$.